Species of ground beetle (Coleoptera: Carabidae) in organic apple orchards of British Columbia

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ABSTRACT

In a two year study, 14 genera of Carabidae (*Agonum* Bonelli, *Amara* Bonelli, *Anisodactylus* Dejean, *Bembidion* Latreille, *Carabus* Linné, *Harpalus* Latreille, *Lebia* Latreille, *Loricera* Latreille, *Poecilus* Bonelli, *Pterostichus* Bonelli, *Scaphinotus* Dejean, *Stenolophus* Stephens, *Syntomus* Hope and *Trechus* Clairville) represented by 44 species were identified from six commercial organic apple orchards in the southern Similkameen valley in British Columbia, Canada; 13 of these species were not native to the area. The 4,299 specimens were caught in 'ramp' pitfall traps, with the genera *Pterostichus* and *Harpalus* comprising 56% and 43%, respectively. Numbers of Carabidae ranged from 11-21 species per orchard, with their presence detected throughout the collection period.

Key Words: Carabidae, diversity, abundance, organic orchards, British Columbia

INTRODUCTION

In North America there are 168 genera and over 2200 species of ground beetle (Coleoptera: Carabidae), most of which are predaceous as adults and larvae (Arnett 1993). Carabids are common in tree fruit orchards (Edwards 1998) and many other agricultural (Levesque and Levesque 1994; Raworth *et al.* 1997) and natural ecosystems (Brumwell *et al.* 1998; Toft and Bilde 2002). Their function as polyphagous predators within orchards was recognized in the 1800's (Lord 1983), and several species are known to prey on key tree fruit pests (MacPhee *et al.* 1988; Pearsall and Walde 1994; Sunderland 2002). Eight species have been reported to feed on larvae of codling moth, *Cydia pomonella* (L.) (Lepidoptera: Tortricidae), one of the key pests of pome fruit in Canada (Hagley and Allen 1988; Riddick and Mills 1994).

Carabids are also considered good indicators of ecological change in different communities (Niemelä *et al.* 1993; Niemelä and Kotze 2000; Szyszko *et al.* 2000; Holland 2002; Holland *et al.* 2002). Unfortunately, many pesticides induce significant levels of mortality in carabids (Eptsein *et al.* 2000; Smith *et al.* 2000; O'Flaherty 2002) and lower levels of fecundity (H. Goulet, Eastern Cereal Oil Research Centre, Ottawa, Ontario, pers. comm.) thereby impacting their potential for natural biological control in agricultural systems. Despite the significance of carabids in orchard habitats there have been few published studies of species diversity in the 27,000 ha of Canadian tree fruit orchards (Herne 1963; Hagley and Allen 1988; Pearsall and Walde 1995).

Carabids typically are sampled using pitfall traps (Spence and Niemelä 1994; Raworth *et al.* 1997). Bouchard *et al.* (2000), improving on the ramp pitfall trap designed by Bostanian *et al.* (1983), developed a trap with plastic ramps connected to the upper lip of a container which rested on the terrain surface. In Nova Scotia, a study to evaluate this modified version of the ramp trap for diversity studies in orchards (Rigby and Smith 2002) indicated a similar

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capture performance to the conventional pitfall trap, yet expressed several advantages including minimized fouling of samples by decomposing plant material and reduced capture of non-target invertebrates. In this study, we used these ramp traps to document carabid species found on the orchard floor of organically managed fruit orchards in the southern Similkameen valley of British Columbia.

MATERIALS AND METHODS

Ramp traps were placed in six commercial, certified organically managed apple orchards in the southern Similkameen valley in British Columbia (119.736 °W, 49.169 °N to 119.753 °W, 49.182 °N) in each of two years (1999-2000). Each trap consisted of two ramps and one plastic container with a removable snap-on lid (Figure 1). The container measured 115 mm in diam and 85 mm in height. Two rectangular notches (45 mm x 40 mm) were cut in opposite sides of the container to hold the ramps in place at an angle < 15° (after Bouchard *et al.* 2000) and to serve as an entrance into the container. The ramps were made of 0.75 mm thick transparent copolyester sheets with the upper surface textured with Speckle Stone black/grey aerosol paint (Crown North America Professional Products, Vaughan, Ontario, Canada). Ramps were 300 mm long and 300 mm wide at the lower surface, tapering to 40 mm at the container entrance. The 22 mm lateral edges were folded up at a 90° angle from the surface of the ramp, and the upper end had a 20 mm flap folded down to anchor the ramp to the container.

All six orchards were part of an area-wide codling moth control program which used a combination of mating disruption and sterile insect release to suppress moth populations (Dyck and Gardiner 1992). Orchards contained a mixture of apple cultivars (mainly McIntosh, Spartan, Red Delicious and Golden Delicious) and ranged in size from 0.5 to 4.4 ha. The orchard floors consisted of bare soil and/or vegetation (mainly orchard grass and broad leaf weeds) and were mowed routinely throughout the cropping season. In each orchard three ramp traps were placed beneath the tree canopy, 15 to 30 m apart. Samples were collected in a salt water solution (with a droplet of detergent) which was replaced when samples were removed, at 7 - 10 day intervals from 23 April - 19 October 1999, and 19 April - 2 November 2000. Samples were stored in 70% ethanol until carabid specimens were sorted and identified to species level using the keys of Canadian and Alaskan Carabidae developed by Lindroth (1961-1969b). Voucher specimens are currently held in the Insect Reference collection at the Agriculture and Agri-Food Canada, Atlantic Food & Horticulture Research Centre, Kentville, Nova Scotia.

Figure 1. Ramp pitfall trap used for collection of Carabidae in organic apple orchards.

RESULTS AND DISCUSSION

In the two years of study 44 carabid species from 14 genera were identified (Table 1), of which 13 species (30% of total) were non-indigenous. Non-indigenous species represented 74% of the 4299 beetles captured. These results are similar to those found in previous studies from Nova Scotia: Pearsall and Walde (1995) collected 28 species from 13 genera, of which nine species (32%) were non-indigenous; Smith *et al.* (2000) reported more than 40 species from 19 genera collected in orchards with 70% of the total beetles captured being non-indigenous; O'Flaherty (2002) collected 55 species of Carabidae representing 18 genera. In that study, almost 90% of the total beetles caught were from the 16 non-indigenous species (O'Flaherty 2002).

In this survey, carabid diversity ranged from 11 to 28 species per orchard block (Figure 2). The most frequently collected genus was *Pterostichus* Bonelli, with one introduced species, *P. melanarius* (Illiger) accounting for almost 56% of the specimens captured in the two years. The second most frequently collected genus was *Harpalus* Latreille, which represented 43% of total captures. Many species (46%) were represented by fewer than three specimens each (Table 1). Carabid densities in apple orchards in southern Ontario were found to be highest in the late summer and fall (Holliday and Hagley 1979). Our data documents similar trends, however, the majority of carabids collected were of two species, *Harpalus pensylvanicus* (DeGeer) and *P. melanarius* (Figure 3).

Published data are sparse regarding carabid prey species, but it is generally noted that there is a positive correlation between the size of beetles and that of prey attacked (Larochelle 1990; O'Flaherty 2002). Three of the carabid species collected in this study, *Amara aenea* (DeGeer), *Harpalus affinis* (Schrank) and *Pterostichus melanarius*, have been reported as codling moth predators (Hagley and Allen 1988; Riddick and Mills 1994), but the orchards used in this survey had low codling moth densities (J. Cossentine, pers. obs.), so it is unlikely that it was a primary source of food for these carabid species. However, the generalist predatory tendencies of carabid beetles make them beneficial in orchard ecosystems, since other important pest species serve as food sources (Larochelle 1990; Sunderland 2002).

The species composition of carabid beetles within orchards and most ecosystems in North America appears to be changing with the arrival and successful establishment of non-indigenous species. Jarrett and Scudder (2001) list 19 new British Columbia carabid records and indicate that several of these have been introduced into North America, some with disjunct east and/or west coast distributions. Clearly, both Atlantic and Pacific coastlines serve as arrival points for many species (Jarrett and Scudder 2001), of which many are well established (Bousquet and Larochelle 1993). Within 10 years, it appears that native *Pterostichus coracinus* (Newman), reported by Pearsall and Walde (1995) as comprising over 40% of ground beetles in Nova Scotia orchards, has been displaced by the introduced *P. melanarius*. O'Flaherty (2002) failed to collect *P. coracinus*, while *P. melanarius* accounted for over 45% of beetles captured in that study. Similarly in Nova Scotia, it appears that the native *Harpalus pensylvanicus* is being displaced by *H. rufipes*, which accounted for a large proportion of the beetles caught by Pearsall and Walde (1995) and O'Flaherty (2002). Although *Pterostichus melanarius* is common in British Columbia (Table 1; Raworth *et al.* 1997), *Harpalus rufipes* (DeGeer) has not yet been recorded in this province (Bousquet and Larochelle 1993). As such, *H. pensylvanicus* is still the most common representative of this genus in orchards.

As carabids represent a yet unresolved biological control resource in Canadian

Table 1.

The number and percentage of Carabidae captured in ramp traps in six organically managed apple orchards in British Columbia for 1999 and 2000. Species marked with an asterisk (*) are non-indigenous.

Species	1999		2000	
	Total	%	Total	%
**Agonum muelleri* (Herbst)	45	4.14	65	2.02
**Agonum placidum* (Say)	1	0.09	15	0.47
**Amara aenea* (DeGeer)	1	0.09	16	0.50
**Amara apricaria* (Paykull)	2	0.18	64	2.00
**Amara aulica* (Panzer)	–	–	1	0.03
Amara avida (Say)	7	0.64	8	0.25
Amara californica californica Dejean	–	–	4	0.13
Amara cupreolata Putzeys	11	1.01	7	0.22
**Amara familiaris* (Duftschmid)	21	1.93	48	1.49
Amara latior (Kirby)	21	1.93	79	2.46
Amara littoralis Mannerheim	–	–	1	0.03
Amara musculis (Say)	–	–	6	0.19
Amara obesa (Say)	–	–	5	0.16
Amara carinata (LeConte)	1	0.09	2	0.06
**Anisodactylus binotatus* (Fabricius)	23	2.12	64	1.99
Anisodactylus californicus Dejean	–	–	1	0.03
Anisodactylus harrisii LeConte	5	0.46	11	0.34
Anisodactylus nigerrimus (Dejean)	4	0.36	84	2.62
**Bembidion lampros* (Herbst)	59	5.43	70	2.18
**Bembidion quadrimaculattum dubitans* (LeConte)	1	0.09	–	–
Bembidion rupicola (Kirby)	1	0.09	–	–
**Carabus granulatus granulatus* Linné	22	2.02	40	1.25
Carabus taedatus Fabricius	1	0.09	–	–
**Harpalus affinis* (Schrank)	87	8.00	118	3.67
Harpalus carbonatus LeConte	1	0.09	–	–
Harpalus fraternus LeConte	1	0.09	2	0.06
Harpalus herbivagus Say	–	–	1	0.03
Harpalus nigritarsis C.R. Sahlberg	1	0.09	3	0.09
Harpalus pensylvanicus (DeGeer)	283	26.03	472	14.69
Harpalus seclusus Casey	33	3.04	47	1.46
Harpalus solitaris Dejean	–	–	1	0.03
Harpalus somnulentus Dejean	–	–	6	0.19
Lebia viridis Say	1	0.09	–	–
Loricera pilicornis (Fabricius)	2	0.18	5	0.16
Poecilus lucublandus (Say)	–	–	10	0.31
Pterostichus adstrictus Eschscholtz	2	0.18	1	0.03
Pterostichus corvinus (Dejean)	1	0.09	–	–
**Pterostichus melanarius* (Illiger)	446	41.03	1951	60.74
Pterostichus mutus (Say)	–	–	1	0.03
Scaphinotus marginatus (Fischer von Waldheim)	–	–	1	0.03
Stenolophus conjunctus (Say)	–	–	1	0.03
Stenolophus unicolor Dejean	1	0.09	–	–
Syntomus americanus (Dejean)	1	0.09	–	–
**Trechus obtusus* Erichson	1	0.09	1	0.03
Total number captured	**1087**		**3212**	

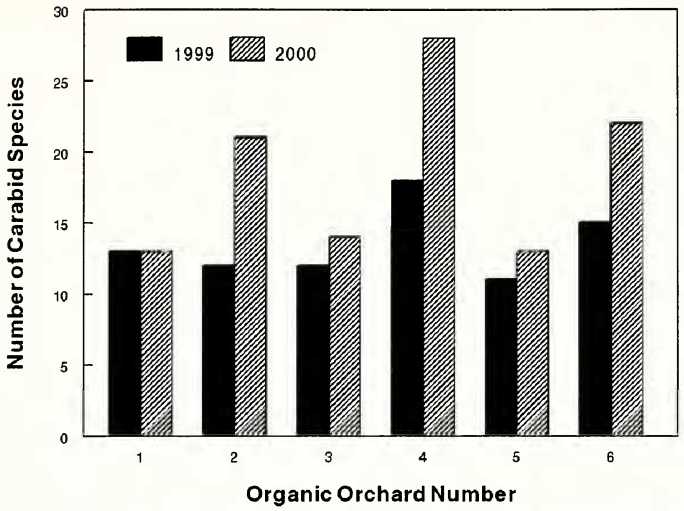

Figure 2. Mean number of Carabidae species captured in ramp pitfall traps in each of six organically managed British Columbia apple orchards in 1999 and 2000.

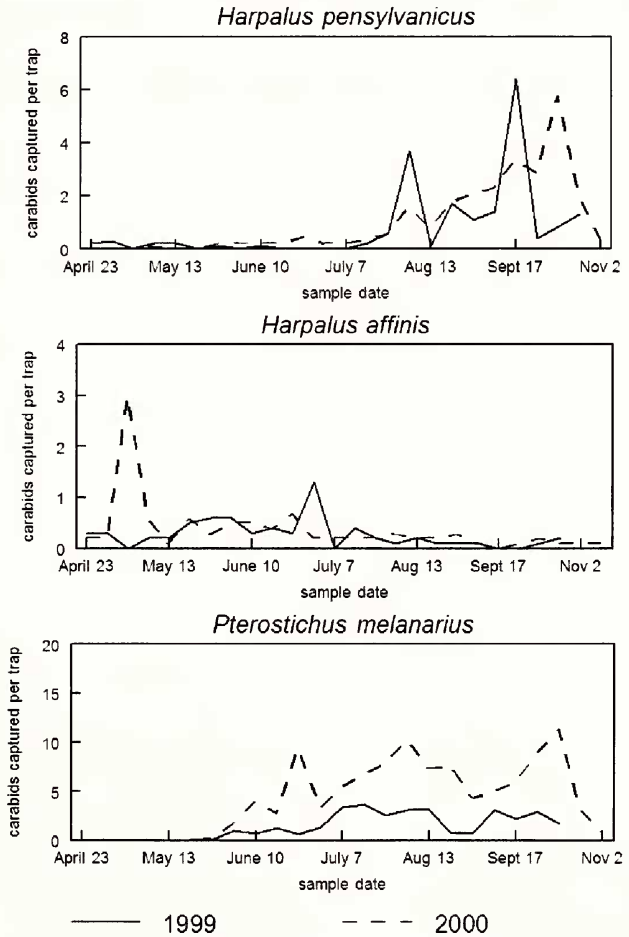

Figure 3. Phenology of three prominent carabid species as monitored by ramp pitfall traps in six organically managed apple orchards in British Columbia: *Harpalus pensylvanicus* (upper graph), *H. affinis* (middle graph) and *Pterostichus melanarius* (lower graph).

orchards, it would be opportune to better understand what they are consuming in the orchards, and how best we can augment their consumption of pest species. This will require further monitoring of carabid populations throughout these ecosystems, and continued assessment of their changing proportions.

ACKNOWLEDGEMENTS

The authors wish to thank Linda Jensen, Pacific Agri-Food Research Centre, Summerland, British Columbia for technical assistance, and Henri Goulet, Eastern Cereal Oil Research Centre, Ottawa, Ontario for confirmation of species identifications.

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